REMARKS

Reconsideration of the above-identified patent application in view of the following remarks is respectfully requested.

Claims 1-33 are in this application. Claims 1-33 have been provisionally rejected under the judicially created doctrine of double patenting. Claims 1-14 have been rejected under 35 U.S.C 112. Claims 15 and 24-33 have been rejected under 35 U.S.C 102(b). Claims 1-14 and 16-23 have been rejected under 35 U.S.C. 103(a). Claim 1, 3-6, 10, 13-17, 19, 20, 24, 27, 28 and 30-32 have been amended. Claims 11, 12, 25 and 26 have been canceled.

The claims before the Examiner are directed to a system and a method for automatic process control of a process.

In many processes, for example processes in the field of silicon chip manufacture, it is not practical to use feedback control systems. Therefore in such processes feed-forward control systems are used, generally based on developing a predictive controller which is substantially a function based on a model simulating the system behavior. The function is configured to receive a vector of process inputs and returns a corresponding process output. In an ideal solution, a statistically significant set of experiments would be performed for each input vector of process inputs to yield an empirically measured actual output for that input vector. However, due to the high price of performing a sufficient number of experiments, such a solution is impractical.

An alternative approach, for example as described in U.S. Patent 6,373,033 (de Waard), is to provide a parameterized model that simulates the process and is used to control the process. In such an approach, experiments are performed in order to allow calculation of values for the parameters of the model. Once the parameters have been calculated, such a model calculates predicted output values for a given input vector.

A weak point in such an approach is the calculation of the parameters. To calculate sufficiently good parameters so that the model produces sufficiently accurate predicted output values, real experiments must be performed. In some processes it is possible to perform a virtually unlimited amount of experiments so that the data set is sufficiently large to give sufficiently accurate parameters. For example, de Waard performs as many experiments as necessary to calculate and subsequently validate the predictions since the measured output values are temperature readings performed in an empty furnace.

A critical problem with such an approach is that in some instances performance of sufficient experiments for the calculation of sufficiently accurate parameters is not possible due to the expense or time required. For example, in a silicon chip manufacturing process it is not possible to perform sufficient experiments due to the high cost of raw materials and the high cost of operating a process just for parameter calculation. Thus the claims before the Examiner present an important innovation that has not been described in the art of process control, that of calculating sufficiently accurate parameters from a very limited number of experiments as described in the claims.

In U.S. 5,781,430 (Tsai) is described a method of simulating a process using a parameterized model made up of a number of equations and identifying an intersection of the equations to identify an "optimum" input vector to run the steady state process. Such a method is not a method of process control to which the present invention belongs, but a method in the entirely different field of optimizing settings of a steady state process that subsequently runs without intervention. A person in the art of process control is seeking to produce a homogenous output (*e.g.*, a series of products of known quality) by manipulating a set of controllable inputs in response to a set of uncontrollable inputs. Such a person would

not seek a solution in the unrelated art of settings optimization where all inputs are controllable and are varied on the basis of a desired output as is found in Tsai.

An additional critical problem known in the art is that the predicted values are necessarily inaccurate. One method of overcoming this inaccuracy is hinted at but not fully described by de Waard where the model parameters are subject to real time assessment and presumably continuous improvement (c. 22, ll. 39-41). The accuracy of values predicted by such an approach remains limited by the fact that any model is a simplification of the actual process no matter how good the parameter values are.

This critical problem is addressed by an embodiment of the invention described in dependent claims before the Examiner, relating to a novel and innovative method of continuously improving the model by monitoring the quality of the actual outputs and using the actual outputs to improve the model until the model becomes ideal, that is, always returns an actual output. A predictive model is provided and parameters of the model calculated using the results of a limited number of experiments, as described above. Predicted outputs for the entire input space are calculated by regression using the predictive model, allowing the process control to be quickly installed and operated. However, during the time that the process is actually performed, actual outputs are gathered and used to replace the predicted outputs, thus improving the produced products. In such a way, the present invention allows for quick and relatively start-up of a process using a predictive model but quickly "learns" by replacing predicted outputs with actual outputs. This is in contrast to the prior are where actual outputs are not features of the respective models.

Amendments to the Claims

In order to expedite the prosecution, Applicant has elected to amend the claims.

Claims 1, 3- 6, 13-16, 17, 19, 20, 24, 26-28 and 30-32 have been amended so as to clarify antecedents and the meaning of terms.

Claim 10 has been amended by the integration of the limitations of claims 11 and 12 dependent therefrom. Claims 11 and 12 have been canceled. Claims 13 and 14 dependent from claim 12 have been amended to depend from claim 10.

Independent claim 24 has been amended by the integration of the limitations of claim 25 and 26 dependent therefrom. Claims 27 and 28 dependent from claim 25 have been amended to depend from claim 24. Claims 25 and 26 have been canceled.

In the amendments, no new material has been added.

Double Patenting Rejections – U.S. 6,766,283

The Examiner has provisionally rejected claims 1-33 under the judicially created doctrine of double patenting over claims 1-26 of copending U.S. Patent Application 09/689,884 which has been issued as U.S. Patent 6,766,283. Applicant respectfully traverses this rejection.

That said, in order to expedite allowance of the claims, Applicant files a Terminal Disclaimer in compliance with 37 CFR 1.321(c) herewith.

35 U.S.C 112 Rejections

The Examiner has rejected claims 1-14 under 35 U.S.C 112, first paragraph as failing to comply with the enablement description. Specifically, the Examiner alleges that the limitations relating to *measurement unit*, *controller* and *regressor* have not been described in

the specification in such a manner as to enable one of ordinary skill in the art to make the invention. The Examiner's rejection is respectfully traversed.

The meaning of the term *measurement unit* in the context of the present invention is clear to one skilled in the art. Every industrial process is provided with a plurality of sensors, detectors and other types of *measurement units*. One skilled in the art desiring to implement the teachings of the present invention in a specific industrial process would be acquainted with available *measurement units* and would not look to the specification for guidance in selecting appropriate *measurement units*. Further, in embodiments of the present invention no special *measurement units* are provided to implement the teachings of the present invention but rather existing *measurement units* are used. Further, in paragraph 71 of the specification (in U.S. 2002/0128805) is described an implementation of the present invention having an Automatic Process Control configured to measure inputs and is therefore necessarily provided with measurement units. Thus, despite the fact that the Examiner states that "*...there are no specifics on the actual operation of...the measurement unit*", Applicant maintains that such are not needed by one skilled in the art in order to implement the teachings of the present invention.

The meaning of the term *controller* in the context of the present invention is clear to one skilled in the art. Every industrial process is provided with at least one *controller* configured to control some, if not all, input parameters. One skilled in the art desiring to implement the teachings of the present invention in a specific industrial process would be acquainted with available *controllers* and would not look to the specification for guidance in selecting an appropriate *controller*. Further, in embodiments of the present invention no special *controller* is provided to implement the teachings of the present invention but rather an existing *controller* is used. Further, in paragraph 71 of the specification (in U.S.

2002/0128805) is described an implementation of the present invention having an Automatic Process Control which necessarily includes a *controller*. Further, shown in Figure 3 and Figure 4 and discussed in paragraphs 80, 81 and 82 of the specification (in U.S. 2002/0128805) are points selected by a controller for an exemplary process. Thus, despite the fact that the Examiner states that "*...there are no specifics on the actual operation of...the controller*" Applicant maintains that such are not needed by one skilled in the art in order to implement the teachings of the present invention.

The meaning of the term *regressor* in the context of the present invention is clear to one skilled in the art from the specification. One skilled in the art recognizes that one simple method of realizing a *regressor* of the present invention is by the use of a computer provided with appropriate software instructions, including a program (*e.g.* Matlab®, The MathWorks, Inc., Natick MA, USA) to perform the actual regression (predicting a value of a variable when given values of other correlated variables, using a functional relationship that is often at least in part empirically determined from data, see Merriam Webster dictionary). To provide guidance to one skilled in the art, Applicant has provided four different general predictive models useful in implementing the teachings of the present invention in Table 1 and the accompanying text. Further, how to calculate the number of experiments required to obtain a predictive model is discussed in paragraph 80 as well as graphically depicted in Figures 9–13; how to determine the input values for the experiments required to obtain a predictive model is discussed in paragraph 82, paragraph 86 as well as graphically depicted in Figures 9–13; how to determine the coefficients necessary for describing a predictive model is discussed in paragraph 85. In addition, starting on paragraph 92, a specific and detailed example is described demonstrating implementation of the teachings of the present invention.

In conclusion, Applicant is of the belief that the terms cited by the Examiner are clear to one skilled in the art and implementable upon perusal of the description.

35 U.S.C 102(b) Rejections – U.S. 5,781,430 (Tsai)

The Examiner has rejected claims 15 and 24-33 under 35 U.S.C 102(b) as being anticipated by Tsai. The Examiner's rejection is respectfully traversed.

As is discussed hereinabove, Tsai describes a method of producing an optimal product where there are a number of possibly conflicting or almost mutually-exclusive product characteristics, the characteristics determined by the settings of a plurality of controllable process inputs. Tsai solves this problem by simulating the process of the production of the product using a parameterized model comprising a number of parameterized equations and identifying an intersection of the equations to identify an "optimum" input vector to run the steady state process. Any time the same process is used to produce a product, the desired qualities are chosen and the optimal set of inputs used to run the process. The process is a steady state process, that is, a process that does not include uncontrolled inputs.

Tsai teaches a method that is not a method of process control to which the present invention belongs, but a method in the entirely different field of optimizing settings of a steady state process that subsequently runs without intervention. A person in the art of process control seeks to produce a homogenous output (*e.g.*, a series of products of known quality) by manipulating a set of controllable inputs in response to a set of uncontrollable inputs. Such a person would not seek a solution in the unrelated art of settings optimization where all inputs are controllable and are varied on the basis of a desired output as is found in Tsai.

Regarding claim 15

Independent claim 15 is of a system comprising a process model using data (including inputs and outputs); a data model for generating data for the process model; and an empirical data extractor for extracting empirical data from the process for the process model, where the process model is configured to use the generated data and the extracted data interchangeably. This latter feature allows the process model to improve with use: initially empirical data is only used as an aid for generating data. With time, when sufficient empirical data is extracted, the empirical data is used interchangeably with the generated data, for example the empirical data is used instead of the generated data. Thus, the system of the present invention can be considered a continuously improving system configured to learn from experience until, as described above, the system provides an ideal solution, that uses only empirical data.

The Examiner alleges that all the limitations of claim 15 are anticipated by the disclosure found on c.13 l.47 – c.14 l.13 of Tsai. As discussed hereinabove, Tsai does not anticipate claim 15 as Tsai does not teach process control and does not even belong in the field of process control. Further, Applicant has reviewed the disclosure of Tsai, including the aforementioned section and found no disclosure of the use of empirical data by a process model to control a process. Rather, in the aforementioned section is disclosed the one time use of empirical data to formulate an empirical mapping function used to construct the process model itself in order to allow determination of inputs appropriate to allow a steady-state process to produce a desired output. There is no mention, suggestion or even hint, neither to use empirical data and generated data interchangeably nor to use empirical data to calculate a process control model. See for example c.13 l. 60 where it is emphasized that the empirical mapping function is formulated only once.

Applicant believes that independent claim 15 and claims 16-23 dependent therefrom are not anticipated by Tsai and are therefore in condition for allowance.

Regarding claim 24

Independent claim 24 has been amended to includc the limitations previously presented in claim 25.

Amended claim 24 is of a method of controlling a process using a data-based process model by generating data for the process model using a data generation formula, controlling the process using the generated data where the process has an input space and the data generation formula is obtained by running the process at preselected points in the space, the points being orthogonally placed in the input space.

Thc Examiner alleges that the limitation of claim 26 (now included in claim 24) is anticipated by the disclosure of Tsai using arguments analogous to those used in rejecting claim 15 as detailed hcreinabove. Applicant believes that for the same reasons presented concerning claim 15, amended claim 24 is not anticipated by Tsai and is therefore in condition for allowance.

Applicant believes that independent claim 24 and claims 27-33 dependent therefrom are not anticipated by Tsai and are therefore in condition for allowance.

35 U.S.C 103(a) Rejections – U.S. 5,781,430 (Tsai) in view of U.S. 6,373,033 (de Waard)

The Examiner has rejected claims 1-14 and 16-23 under 35 U.S.C 103(a) as being unpatentable over Tsai in view of de Waard. The Examiner's rejection is rcspectfully traversed.

As discussed above Tsai teaches a method that is not a method of process control to which the present invention belongs, but a method in the entirely different field of optimizing settings of a steady state process that subsequently runs without intervention. A person in the art of process control seeks to produce a homogenous output (*e.g.*, a series of products of known quality) by manipulating a set of controllable inputs in response to a set of uncontrollable inputs. Such a person would not seek a solution in the unrelated art of settings optimization where all inputs are controllable and are varied on the basis of a desired output as is found in Tsai.

De Waard discloses a predictive control system using parameterized equations to simulate the process. De Waard gathers extensive experimental data (starting c. 19 l. 55, specifically c. 20 l. 14 and c. 21 l. 46. De Waard does not teach the use of orthogonally placed preselected points of the input space.

Tsai and de Waard do not teach all of the features of the rejected claims, neither separately nor in combination. Further, there is no evidence that one skilled in the art would be motivated to combine the teachings of de Waard from the field of process control with any aspect of the unrelated field of input determination for a process including only controllable parameters.

Regarding claim 1

The Examiner has rejected independent claim 1.

Claim 1 describes a system for automatic process control using a predictive model, where the predictive model is configured to predicted outputs. The predicted model is obtained using a regressor that allows obtaining the predicted model with measured outputs from only a limited number of experiments.

De Waard does not disclose, mention or even hint at the use of a regressor, nor obtaining a model with anything but extensive experimentation.

Tsai does not teach a method of providing process control.

Further, even if one skilled in the art was acquainted with the teachings of Tsai and de Waard, such a person would not be motivated to apply the teachings of Tsai, directed at providing parameters for a process where all inputs are controllable to the field of process control where at least some of the inputs are substantially uncontrollable and variable.

Applicant believes that since not all limitations of claim 1 are disclosed in Tsai or de Waard, independent claim 1 and all claims dependent therefrom are in condition for allowance.

Independent claims 1, 15 and 24 feature language that is neither anticipated by nor obvious in light of the art. Applicant is of the opinion that independent claims 1, 15 and 24, and consequently all claims dependent therefrom, are in condition for allowance. Applicant respectfully requests that a timely Notice of Allowance be issued in this case.

Respectfully Submitted,

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